AGENDA ITEM K-01

CITY OF LODI
COUNCIL COMMUNICATION

TM

AGENDA TITLE: **Approve Recommendations for Preferred Site and Treatment Technology for Lodi Surface Water Treatment Facility**

MEETING DATE: **October 17, 2007**

PREPARED BY: **Public Works Director**

RECOMMENDED ACTION: Approve the staff recommendations for the preferred site selection and the selection of membrane treatment technology for the Lodi Surface Water Treatment Facility.

BACKGROUND INFORMATION: At previous Council meetings, staff and the consulting firm, HDR, presented the results of a study that considered five alternative sites for the new Surface Water Treatment Facility (SWTF) with the objective to receive site selection direction from the City Council early in the program. At these meetings, we also noted that among the "next steps", a presentation and request for approval would be made in October 2007 on the preferred treatment technology.

The five alternative sites (as shown on Exhibit 1) are listed below, along with comments as to their suitability:

A – The vacant 13 acres at the west side of Lodi Lake – recommended site (City-owned, lowest cost, park/educational benefits)
B – The General Mills orchard property west of Site A – suitable site (similar to Site A but privately owned, no park benefit)
C – The "scenic overlook" site at the end of Awani Drive at the Mokelumne River – not recommended (although City-owned, significant additional cost for new River intake and fish screen and delay for State/Federal permitting)
D – Along the Woodbridge Irrigation District (WID) Canal, 0.6 miles northwest of the corner of Lower Sacramento Road and Sargent Road, immediately west of the proposed Westside residential development project – not recommended (privately owned, additional pipe and land costs)
E – Along the WID canal, just north of Turner Road – not recommended (privately owned, additional pipe and land costs)

Council directed staff to contact General Mills regarding Site B. General Mills Site Manager, Carson Funderburk, has responded to the City Manager that they have potential long-term plans for the property and that it could be three to five years before they could determine if property was available. Since we cannot wait that long and the Council has not indicated that it would be willing to use eminent domain to acquire property, staff believes that Site A, the Lodi Lake property, is the best available site. We are confident that the facility can be designed and constructed to be not only compatible with future park uses but will actually enhance the area. Very preliminary conceptual plans and photographs will be presented at the meeting, however, much work and future decisions will need to be made regarding the site, including:

- Develop a master site plan for the entire parcel, including the SWTF and park uses

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APPROVED: ______________________________
Blair King, City Manager

- Plan for shared facilities and improvements as much as possible to be efficient in terms of land usage (such as roadway access, parking, restrooms)
- Attempt to minimize land needs; for example, consolidating plant elements in fewer buildings
- Design the facility with site and architectural enhancements to improve the park
- Have the SWTF facility itself provide public benefit through development of a viewing/educational multi-purpose room, possibly as a replacement for the aging Discovery Center currently located in the old snack bar at Lodi Lake
- Having the project literally pay the General Fund for the site is within the discretion of the Council. Staff has assumed that the compensation and/or mitigation for park impacts would be in the form of enhanced or additional improvements as part of the SWTF project. This does not need to be determined at this time but should be considered in the design and financing stages.

During the discussions over the site, our consultants have completed the technology assessment for the SWTF (attached). The recommendation is for a membrane filter system rather than "conventional" filtration. Conventional filters use sand or other media to filter water that has chemicals added to "flocculate" the water in order for the sand/media to remove fine material. Membranes are layers of ceramic or other material with very small pores through which the water is pumped and very fine material is removed from the water. The advantages of membrane systems over "conventional" include:

- "Membranes provide a positive barrier for the removal of all microbials and most pathogens, which increases the flexibility of the system to meet future regulations."
- The facility footprint can be smaller and easier to expand.
- The facility can be more automated, reducing personnel requirements.
- The process requires less pretreatment or chemical addition.
- Costs are similar, perhaps slightly less.

"Next steps" in this project process will be to refine the site layout; complete the watershed assessment; and perform geotechnical work, evaluation of environmental considerations, distribution system modification evaluation and phasing/cost estimates. The phasing and cost estimates will be used in the financing model which is scheduled for Council presentation and direction in early 2008.

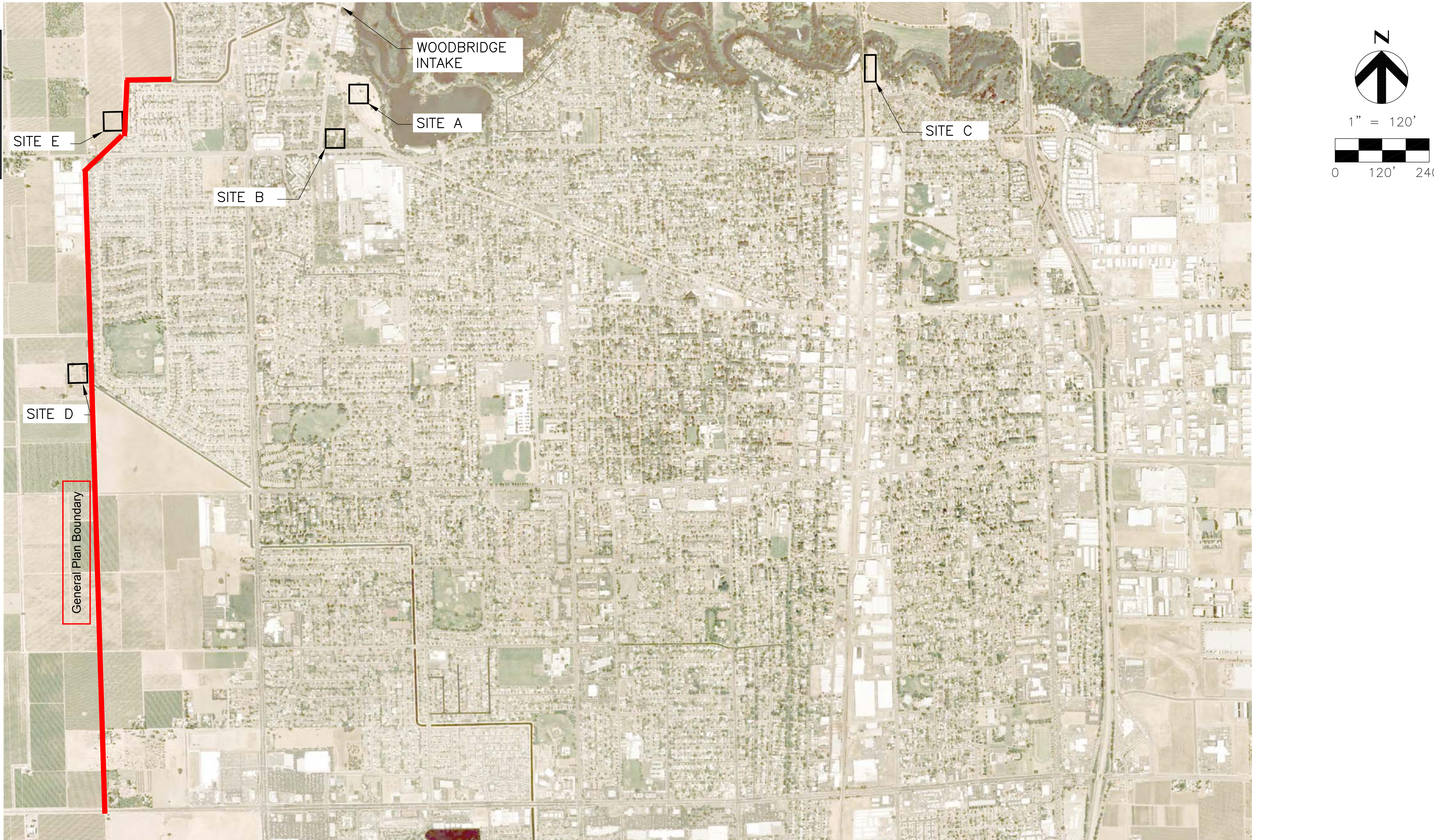
FISCAL IMPACT: Site A is the recommended site for the Surface Water Treatment Facility and, if selected, could realize a reduced capital expenditure in excess of $1,000,000 or provide additional public park improvements.

FUNDING AVAILABLE: Not applicable at this time.

Richard C. Prima, Jr.
Public Works Director

RCP/pmf
Attachments

Exhibit 1



HDR

ALTERNATIVE SWTF SITE LOCATIONS

CITY OF LODI – SURFACE WATER TREATMENT FACILITY

DATE 6/19/07

FIGURE 1

TM 5 – SWTF TREATMENT PROCESS DESIGN DEVELOPMENT

City of Lodi Surface Water Treatment Facility Conceptual Design and Feasibility Evaluation ***October 10, 2007***

Reviewed by: Richard Stratton, P.E.

Prepared by: Shugen Pan, PhD, P.E.

Introduction

The proposed Surface Water Treatment Facility (SWTF) project will treat surface water from the Mokelumne River to supplement the City's existing groundwater supply. Treatment technologies available for the SWTF include either a conventional process consisting of coagulation, flocculation, sedimentation, dual media (anthracite/sand) filtration; or a membrane treatment process utilizing microfiltration or ultrafiltration membranes. The purpose of this technical memorandum (TM) is to establish design criteria for both conventional and membrane treatment processes at the proposed SWTF, evaluate the advantages and disadvantages of each process, and recommend the best treatment process. The process schematic, preliminary site plan showing the layout and required footprint, improvements needed to provide access to the site, hydraulic profile, and preliminary floor plans for key buildings will be presented for the recommended process.

Additional elements of the project that are covered in other TMs include:

TM 2 - Alternative Site Selection – Initial Screening
TM 3 - Watershed Assessment
TM 4 - Regulatory Review
TM 6 - Surface Water and Groundwater Blending

These TMs will develop information that may modify the final design criteria of the recommended treatment process. However, the comparison evaluation of the processes will not be affected by these changes. For example, TM 6 may recommend addition of polyphosphates to stabilize corrosion scales in the existing piping after introduction of surface water. This would be required for either a conventional or a membrane process and would not change the decision on which alternative is preferred.

Basic Design Criteria for Both Conventional and Membrane Treatment Alternatives

The basic design criteria for a water treatment plant are established to address raw water quality challenges, to comply with current and future regulations, and to reliably operate to meet the anticipated range of water demands. The basic design criteria common to both conventional and membrane treatment alternatives can be divided into three groups: raw water quality, treatment capacity/reliability, and treated water quality/regulatory compliance.

Raw water quality

The proposed City of Lodi SWTF will treat water from the Mokelumne River through the Woodbridge Irrigation District (WID) irrigation canal intake and fish screen. The water quality is evaluated in detail in the future watershed assessment TM and is briefly summarized in Table 1.

It should be noted that data represent the general quality of the water at the sampling sites. Additional sampling has been performed by City Storm Water trackers during the winter season. This data has shown that the raw water turbidity could be greater than 50 NTU during a storm event.

Overall, the Mokelumne River is an excellent water source that has low total dissolved solids (TDS) and total organic carbon (TOC) concentrations. The levels of total coliform and *Giardia* Cysts are slightly elevated, but these can be effectively removed by membranes or the combination of conventional filtration followed by ultraviolet disinfection.

Table 1
Water Quality Data from Mokelumne River and WID Canal Sampling Sites, May 2006-July 2007

	Site 1: Mokelumne River[1]			Site 2: WID Canal Near River[2]			Site 3: WID Canal Past Raleys[3]			Site 4: Woodbridge Dam[4]		
Constituent	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean
pH, SU	8.6	6.2	7.4	7.8	6.3	7.1	7.8	6.3	7.1	8.8	7.7	8.0
Total dissolved solids, mg/L	45	25	31	42	25	32	43	22	31	45	24	35
Specific conductance, µS/cm	52	32	40	48	31	39	52	32	39	44	35	39
Turbidity, NTU	5.7	1.3	2.6	4.3	1.0	2.5	3.5	1.1	1.9	3.4	1.4	2.4
Alkalinity, mg/L	23	15	<20	21	<20	6	22	16	10	<20	<20	<20
Hardness, mg/L	16	13	14	15	13	14	16	13	14	14	13	14
Calcium, mg/L	4	3.4	3.6	4.0	3.5	3.7	4.1	3.5	3.7	3.7	3.5	3.6
Iron, mg/L	0.20	<0.10	0.15	0.17	<0.10	0.13	0.12	<0.10	<0.10	0.23	0.12	0.16
Magnesium, mg/L	1.3	1.0	1.2	1.3	1.1	1.2	1.3	1.1	1.2	1.2	1.1	1.2
Copper, µg/L	5.8	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Zinc, µg/L	27.0	<5.0	9.6	31.0	<5.0	10.2	32.0	<5.0	13.2	8.1	<5.0	<5.0
Total organic carbon, mg/L	2.7	1.1	1.5	2.9	<1.0	1.7	2.8	1.1	1.6	1.6	1.2	1.4
Dissolved organic carbon, mg/L	2.4	<1.0	1.0	2.5	1.1	1.5	2.5	<1.0	1.3	1.5	1.1	1.3
Total coliform, MPN/100mL	1600	60	509	>1600	240	1019	>1600	300	1030	1600	170	766
Fecal coliform, MPN/100mL	140	13	69	170	13	59	900	30	330	140	23	75
Giardia, cysts/mL	9.5	<0.5	2.0	4.0	<0.5	1.0	4.5	<1.0	2.1	4.0	<0.5	<0.5
Cryptosporidium, oocysts/L	<0.10	<0.05	<0.05	0.05	<0.05	<0.05	<0.1	<0.05	<0.05	<0.1	<0.05	<0.05
VOCs, µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SOCs, µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Source: City of Lodi Public Works Department, 2007

[1] Mokelumne River shore on north side of Vaccarreza property (1300 block E. Turner Road); 15 samples from May 3, 2006 through July 18, 2007
[2] WID Canal from bridge over canal on Orange Street; 10 samples from May 3 through October 11, 2006 and April 4 through July 18, 2007
[3] WID Canal past Raleys from bridge on Lower Sacramento Road by well 13; 10 samples from May 3 through October 11, 2006 and April 4 through July 18, 2007
[4] Just upstream from Woodbridge Dam; 5 samples from November 29, 2006 through March 7, 2007

Key: µg/L = micrograms per liter
mg/L = milligrams per liter
MPN/ 100mL = most probable number per 100 milliliters
ND = not detected
NR = not reported
NTU = nephelometric turbidity unit
µS/cm = microSiemens per centimeter

Treatment capacity/reliability

Background

The City currently uses groundwater as its sole source of supply. A total of 26 groundwater wells located throughout the City's distribution system provide a combined capacity of 35,210 gallons per minute (gpm) or 50.7 million gallons per day (mgd) based on the City's 2005 Urban Water Management Plan (UWMP). The City has historically used from 11,462 AFY of groundwater in 1970 to 17,108 AFY in 2001. Historical data indicate that the City's groundwater elevation decreased on average 0.39 feet per year from 1927 to 2004, although groundwater elevation also fluctuates due to annual rainfall. Historical groundwater elevation and annual rainfall are presented in Figure 1.

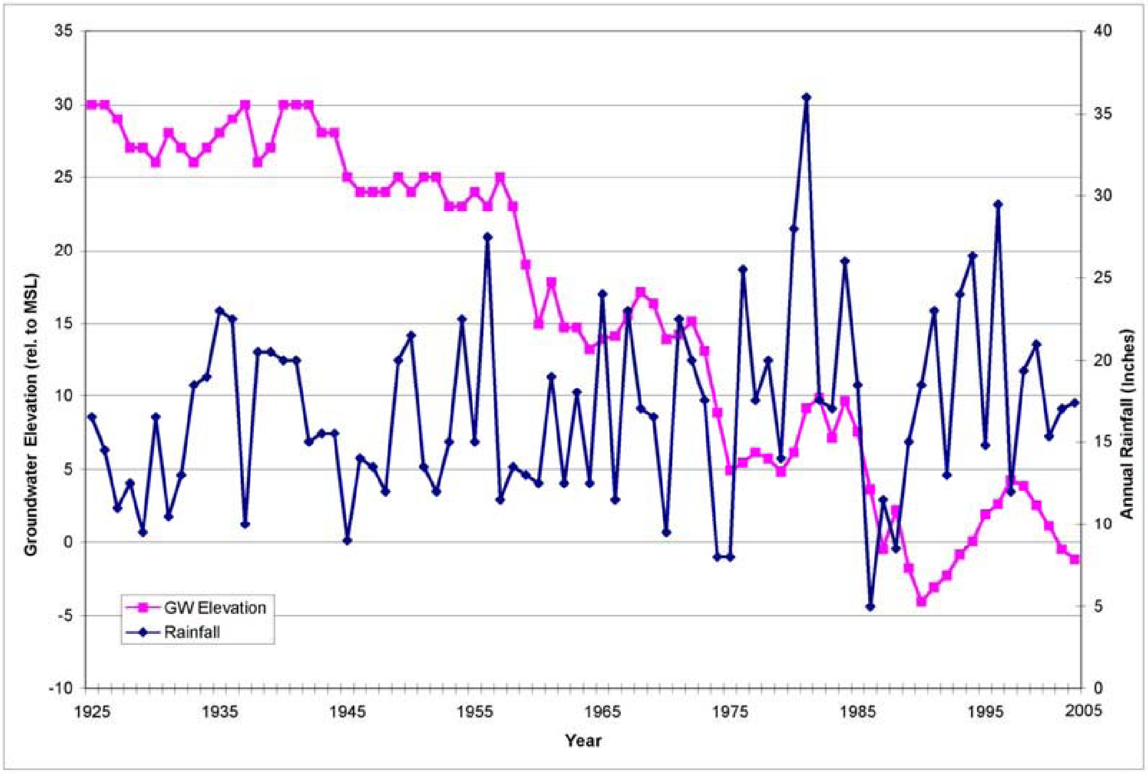


Figure 1. Historical groundwater elevation and annual rainfall

This figure indicates that the groundwater basin underlying Eastern San Joaquin County that supplies the City's wells is in an overdraft condition. The 2005 UWMP estimates that the safe yield of the underling groundwater basin is approximately 15,000 AFY on an acreage-based relationship although more rigorous scientific analysis could be done to confirm the safe yield. The declining groundwater basin is a result of groundwater extraction by all groundwater users in the area, including other cities, agriculture, private well owners, and the City. The City plans to reduce its groundwater pumping in the long term as part of a regional effort to stabilize the groundwater basin.

Water demand

The 2005 UWMP reports that City's average annual water demand for the period 1995 to 2004 was 14.94 mgd. The maximum day peaking factor (the maximum demand divided by the average annual demand) for the City's water demand ranged from 1.80 to 2.30 with an average of 1.91 The maximum month demand typically occurs in either August or July with a peaking factor of 1.7. The monthly demand during the year based on 2005 and 2006 demand data is presented in Table 2

Table 2. Monthly Demand Data

Month	Average Monthly Demand, mgd	Peaking Factor - (Monthly Demand/Annual Average Demand)
January	7.6	0.52
February	7.9	0.54
March	8.1	0.56
April	9.9	0.68
May	16.5	1.13
June	21.3	1.46
July	24.8	1.70
August	23.8	1.63
September	20.2	1.39
October	15.7	1.08
November	11.0	0.75
December	8.2	0.56
Annual Average	14.58	

Based on the historical peaking factor and the projected water demand, the year is divided into 3 seasonal demand groups: summer, spring-fall, and winter. Projected potable water demands for each are season presented in Table 2. These values assume water conservation practices will be implemented as described in the UWMP.

Table 3. City of Lodi Current and Projected Total Water Demand (Ref. 2005 UWMP)

Demand Criteria	Units	2005	2010	2015	2020	2025	2030
Annual demand	AFY	17,300	17,900	18,400	19,100	19,800	21,300
Average Annual Daily Demand	MGD	15.4	16.0	16.4	17.1	17.7	19.0
Summer (June–September) Average Daily Demand*	MGD	24.6	25.6	26.2	27.4	28.3	30.4
Spring-Fall (April, May, October, November) Average Daily Demand *	MGD	15.4	16	16.4	17.1	17.7	19
Winter (December–March) Average Daily Demand *	MGD	9.2	9.6	9.8	10.3	10.6	11.4

*Summer (1.6 x annual average); Spring-Fall (1.0 x annual average); Winter (0.6 x annual average)

Water supply

Based on the UWMP, the projected potential potable water supply for the City includes 15,000 AFY of groundwater and 6,000 AFY of WID surface water. The projected 15,000 AFY of groundwater is based on the estimated safe yield, however, this estimate is not guaranteed. The actual safe yield could be less than projected, and it will depend on the cooperation of all other groundwater users to be sustainable. Recycled water usage is covered in TM 11 - Phased Capacity Analysis. Demands associated with current reclaimed water usage at the White Slough Facility are not included in the demands listed in Table 3. Although the recycled water could be a reliable source to offset some potable water usage, the water quality is not as good as potable water and the public may be reluctant to accept is as a supplemental source for current potable water uses.

To increase the flexibility and reliability of the City's water supply, the City is actively exploring possibilities with the WID and East Bay Municipal Utility District (EBMUD) to use more of the Mokelumne river water. It is expected that up to 6,000 AFY additional surface water could be acquired. Considering both the contracted surface water and the additional surface water available pending negotiation, the total available surface water could be as much as 12,000 AFY. This is equivalent to 10.7 million gallons per day (mgd) assuming year-round operation, or 17 mgd if water usage is limited to March 1 through October 15.

The current groundwater supply is provided by 26 wells with capacities ranging from 1.2 to 3.0 mgd. When determining the maximum surface water usage possible during the winter, consideration must be given to the fact that the wells must be operated on a maximum 3-day rotation to ensure well good performance. This means that 8 wells must be operated every day for at least 6 hours (2 wells running at all times). Assuming an average well capacity of 2 mgd, the most surface water that can be used during the winter months on an average in 2030 would be 6.5 mgd.

Treatment capacity

The capacity of the SWTF should be sufficient to treat the contracted surface water, banked water, and future surface water supplies. The required capacity of the SWTF is dependent on whether it is operated year round or only during the irrigation season (from March 1st to October 15th). Higher capacity is needed if the facility is operated during the irrigation season only. The SWTF should be designed to treat the maximum amount water available during the year and allow operation at maximum capacity during the summer high demand months and at lower capacity during the winter so that the groundwater wells can be exercised sufficiently. The SWTF should also be designed with sufficient reliability. Key unit processes in the treatment train will utilize the N+1 approach, i.e., capacity will be based on one unit off-line. The required treatment capacities of the SWTF by season for utilizing the maximum water supply from the Mokelumne River for the year 2030 demands are summarized in Table 4. The required capacities are shown for both year round operation and for operation only during the irrigation season.

Table 4. Required Treatment Capacities of the SWTF based on Year 2030 Demands

Demand Criteria	Summer	Spring and Fall	Winter
Year Round Operation			
Maximum Day	16 mgd	14 mgd	7 mgd
Minimum Day	12 mgd	10 mgd	5 mgd
Average Day	14 mgd	12 mgd	6 mgd
March 1 through October 15 Operation			
Maximum Day	26 mgd	14 mgd	7 mgd
Minimum Day	20 mgd	10 mgd	5 mgd
Average Day	23 mgd	12 mgd	6 mgd

The design capacity required to fully utilize the 12,000 AFY of water contracts for year round operation is 16 mgd. If operation is limited to the irrigation system, a plant capacity of 26 mgd would be required.

For the initial phase (year 2010) of the project, it is assumed that that 3,000 AFY of banked water would be used along with the 6,000 AFY contract amount. The required treatment plant capacities by season for the initial phase are shown in Table 5.

Table 5. Required Treatment Capacities of the SWTF based on Initial Phase Demands Using Banked Water

Demand Criteria	Summer	Spring and Fall	Winter
Year Round Operation			
Maximum Day	12 mgd	10 mgd	7 mgd
Minimum Day	8 mgd	6 mgd	5 mgd
Average Day	10 mgd	8 mgd	6 mgd
March 1 through October 15 Operation			
Maximum Day	18 mgd	12 mgd	7 mgd
Minimum Day	13 mgd	8 mgd	5 mgd
Average Day	16 mgd	10 mgd	6 mgd

Based on the initial demands including use of banked water, it is recommended that the City construct the SWTF in two phases. The first phase shall have a summer capacity of 12 mgd and leave room for a second phase expansion of 4 to 6 mgd. The size of the first phase and second phase expansion will depend on the actual amount of future water supply and whether or not the plant operates year round. The following sections are based on an initial firm treatment plant capacity of 12 mgd.

Treated water quality / Regulatory compliance

The treated water quality goals for the SWTF are based on an assessment of regulatory requirements (both existing and future), maximum contaminant level (MCLs), required treatment techniques (TT), secondary standards, required pathogen log removals, and aesthetic water quality goals. Pathogen log removal is based on taking the converting the logarithm of (1- minus the percent removal (as a fraction) to a positive number. For example, 99.9 percent removal is equal to a 3-log removal [-log(1-0.999)]. The water quality goals for this project are summarized in Table 6.

Table 6 – Treated Water Quality Goals

Contaminant/Parameter	Treated Water Goal	MCL or TT	Secondary Standard
Arsenic (mg/L)	<0.008	0.010	
Fluoride (mg/L)	< 2.0	4.0	2.0
Nitrate as N (mg/L)	<8.0	10	
Nitrite as N (mg/L)	<0.8	1	
Gross Alpha (pCi/L)	<10	15	
Uranium (ug/L)	<10	30	
Total Trihalomethanes (TTHM) (ug/L as LRAA)	<64	80	
Haloacetic Acids (HAA) (ug/L as LRAA)	<48	60	
Turbidity (NTU)	<0.3	TT(1)	
Aluminum (mg/L)	<0.05		0.05 to 0.2
Chloride (mg/L)	<100		250
Color (color units)	<5		15
Copper (mg/L)	<0.8		1.0
Iron (mg/L)	<0.3		0.3
Manganese (mg/L)	<0.05		0.05
Odor (TON)	<3		3
pH	7.5-8.3		6.5-8.5
Sulfate (mg/L)	<100		250
Total Dissolved Solids (mg/L)	<300		500
Zinc (mg/L)	<5		5
Cryptosporidium	4 log removal/inactivation	TT(2)	
Giardia lamblia	4 log removal/inactivation	TT(2)	
Viruses	4 log removal/inactivation	TT(2)	

TT: Treatment Technique

(1) Combined filter effluent turbidity <0.3 NTU in 95% of measurements taken each month. The maximum turbidity is 1 NTU.

(2) Minimum 3-log removal/inactivation of Giardia (99.9%); minimum 4-log removal/ inactivation of viruses (99.99%); and minimum 3-log to 5.5-log removal/inactivation of Cryptosporidium depending on the source water quality.

Review of Appropriate Treatment Technologies

The typical water treatment process train includes three basic unit operations: pretreatment, filtration, and disinfection. In addition to the basic unit operations, other treatment units or chemicals are often included to optimize water treatment and achieve better treated water quality. These treatment units include grit removal, oxidation chemicals, powdered activated carbon (PAC) and corrosion inhibitors. For some waters advanced treatment such as granular activated carbon (GAC) and nanofiltration or reverse osmosis (NF/RO) are included in the process. The treatment processes that would be appropriate for treating raw water from the Mokelumne River via the new WID intake are summarized in Table 7.

Table 7. Appropriate Treatment Processes for Mokelumne River Water Supply

Treatment Category	Appropriate Unit Processes
Pretreatment	• Conventional Coagulation/Sedimentation • Coagulation for Direct Filtration • Dissolved Air Flotation • Sludge Blanket Clarifiers • Ballasted Clarification • Plate or Tube Settlers
Filtration	• Conventional Dual Medial Filters • Microfiltration or Ultrafiltration (Membrane Filtration)
Disinfection	• UV • Chlorine • Chloramines • Ozone
Oxidation	• Ozone • Chlorine Dioxide • Chlorine • Chloramines • Potassium Permanganate • Hydrogen Peroxide
Other Chemicals	• Powdered Activated Carbon (PAC) • NaOH • Corrosion Inhibitors
Alternative Advanced Processes*	• GAC • Nanofiltration or Reverse Osmosis

*These processes are for enhanced Total Organic Carbon (TOC) and /or Total Dissolved Solids (TDS) removal and are not necessary for this project.

Theoretically, there are forty-eight possible treatment trains based on the pretreatment, filtration, and disinfection alternatives listed in the above table. If oxidation and advanced treatment are included in the consideration, the possible trains are much more. To simplify the evaluation process, only the most feasible treatment processes, based on a review of industry experience with these unit processes, are selected for evaluation. First, two filtration technologies (i.e. conventional dual media filtration and membrane filtration) are selected as the base unit of each treatment trains. The full treatment trains are developed by expanding the base unit with the addition of pretreatment and disinfection technologies that are most feasible when combined with the base unit, considering raw water quality, treated water quality goals, existing and future regulations, and engineering judgment. The following sections will review appropriate treatment processes for treating Mokelumne River water (including pretreatment, filtration, and disinfection) technologies and determine their suitability to the proposed SWTF.

Pretreatment Alternatives

Conventional Sedimentation

Conventional sedimentation involves chemical addition, rapid mixing, coagulation, flocculation, and sedimentation. This process has been demonstrated to be capable of removing turbidity, color, TOC, Dissolved Organic Carbon (DOC), viruses, bacteria, and protozoans such as *Giardia* and *Cryptosporidium*. This pretreatment alternative can cope with source water turbidity up to 1,000 NTU or higher and is a reliable pretreatment alternative for both membrane and conventional filters.

Conventional flocculation and sedimentation basin (Yuba City)

Coagulation and Flocculation for Low Turbidity Waters

If the raw water source has low turbidity such as found in lakes, reservoirs or rivers flowing out of lakes/reservoirs, pretreatment consisting of coagulation followed by flocculation may provide sufficient pretreatment prior to filtration. This approach is often called direct filtration. Since sedimentation basins are not required, costs are lower for direct filtration plants than for conventional plants. Coagulation followed by direct filtration with media filters generally requires that the average raw water turbidity is less than 10 NTU and thus will not be feasible for dual media filtration at the proposed SWTF if year round operation is desired. In addition, DHS regulations provide a lower *Giardia* log removal credit of 2.0 for direct filtration which would necessitate a more robust disinfection system to achieve the 3.0 log total log removal requirement. In many cases, if there is a concern with elevated levels of bacteria or cysts in the water supply, the Department of Public Health will require full conventional treatment and not allow direct filtration.

On the other hand, coagulation followed by membrane filtration has been frequently used to treat surface water with inlet turbidity as high as 100 NTU for short durations. An example is the Yucaipa Valley Water District membrane WTP that treats water from California Aqueduct via Lake Silverwood and the Crafton Hills Reservoir without pretreatment. Given the comparable quality of the Mokelumne River to the water leaving Lake Silverwood, it is expected that coagulation with direct membrane filtration will do well at the proposed SWTF.

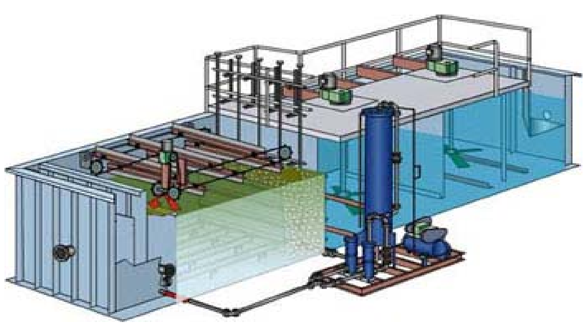
Dissolved Air Floatation

Dissolved air floatation (DAF) is based on the principle that the naturally occurring and coagulated particles can be made to float with the help of dissolved air bubbles. The flocculation time used in DAF plants are typically less than those used by conventional coagulation sedimentation plant. Advantages of DAF include:

- Small tanks compared with those for sedimentation
- Possibly lower coagulant and flocculent aid dosages, can operate without polymer addition
- Provide better removal of low density particles and algae
- Greater sludge solids concentration.

DAF is a suitable pretreatment for both media filter and membrane filters for the proposed SWTF.

Schematic of DAF



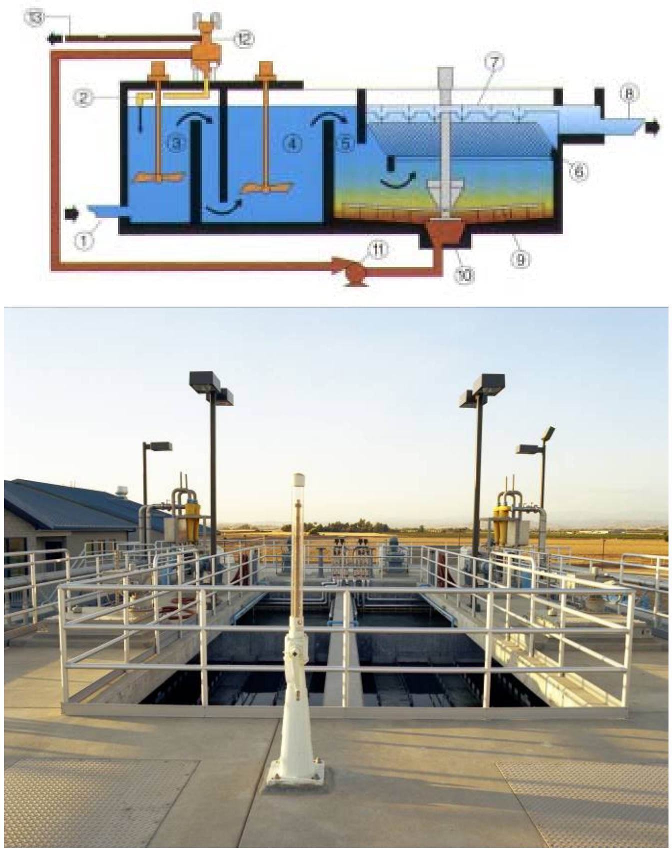
Sludge Blanket Clarifiers

Sludge blanket clarification, or solids contact clarification, involves coagulation within a mass of previously formed solids. Coagulation chemicals are added in a rapid mixing chamber and the water and resulting particles then percolate upward through a sludge blanket. The contact between the newly flocculated particles and the existing mass in the sludge blanket aids in the removal of particles from the water because newly formed particles readily adsorb onto existing particles. During stable operation, the sludge blanket clarifier can generally produce lower turbidity water compared with the conventional sedimentation basin. One disadvantage of the sludge blanket clarifiers is the blanket stability can be disrupted during flow changes, abrupt water quality changes, or temperature changes, resulting floc carryover to the filters. Sludge blanket clarification is a viable pretreatment for both media and membrane filtration.

Ballasted Clarification

Ballasted clarification is a high-rate clarification system (e.g., Actiflo by Kruger), which includes separate chemical addition, followed by rapid mixing, flocculation, and sedimentation compartments within a single unit. The process utilizes microsand to enhance flocculation and settling. Settleable particles adhere to the microsand and are removed in the sedimentation compartment. The settled solids/microsand is pumped to a hydrocyclone where the microsand is separated and returned to or reused in the flocculation compartment. The solids/sludge is discharged to the solids handling process.

The advantages of ballasted processes are the reduced coagulation and flocculation times and the higher rise rate compared to conventional settling. The ballasted flocculation process has been successful even under extreme conditions such as low temperature, high color, and very high or very low turbidities. Ballasted flocculation is expected to perform well as the pretreatment alternative for media filters. Ballasted clarification has also been used ahead of membrane filters, however, testing at many facilities indicates that polymer carryover can occur causing rapid fouling of the membranes. Ballasted clarification would not be the best fit for the proposed SWTF if membranes are selected.



Schematic of ACTIFLO and ACTIFLO Facility (City of Fresno)

Plate and Tube Settlers

Plate and tube settlers are very similar in nature and only plate settler will be discussed here. Plate settlers perform the same function as conventional sedimentation basins and can be installed in the same location in the process train. Flocculated water enters the plate settler at the bottom of the plates and flows through the inlet channel to each plate. Water enters the settling area between the inclined plates through openings on both sides of the plates, and flows upward between the plates to the outlet area. Settled solids slide down the inclined surface and drop into the basin below.

Plate settlers allow for overall basin loadings from 2 to 4 gpm/ft^2, several times that for conventional basins, thus offering considerable savings in space and cost for sedimentation. Plate setters are expected to perform well as the pretreatment for both media filter and membrane filter for the proposed SWTF.

Stainless Plate Settler installed in Sedimentation Basin (Kennewick, WA)

Filtration Alternatives

Filtration is the heart of surface water treatment plants and is needed for most surface waters in order to provide a barrier against the transmission of waterborne diseases. Filtration and disinfection together provide an effective barrier against pathogens. Filtration can assist significantly by reducing the load on the disinfection process and increasing disinfection efficiency. Filtration can be divided into two basic types: media filtration and membrane filtration. Each type of filtration will be briefly discussed in the following sections.

Media Filtration

Media filtration can include slow sand filtration (0.05 to 0.1 gpm/ft^2), rapid sand filtration (1 to 2 gpm/ft^2), high-rate granular media filtration (up to 10 gpm/ft^2 or even higher), Diatomaceous Earth (DE) filtration, and those used in pressure filters such as green sand filtration. High-rate granular media filtration is the most commonly used media filtration in modern surface water treatment plants and will be the basis of this evaluation. Media configuration in the high-rate granular media filter can be 1) conventional sand; 2) dual-media (coal over sand); 3) mixed media (coal over sand over garnet); and 4) deep bed (coarse sand or coal, unstratified, 48 to 72 inches). Granular activated carbon (GAC) caps, a layer of GAC on top of the filter media, has also been frequently used to improve filtration and organic removal.

Effective operation of a media filtration system requires effective pretreatment of the source water. The nature, as well as the quantity, of suspended material in the pretreated water can greatly influence filter performance. The most commonly used filtration pretreatment process is coagulation/flocculation and sedimentation. Unflocculated water can be difficult to filter regardless of the type of medium used.

With proper pretreatment, media filters typically can operate from 12 to 96 hours before either reaching the head loss limit or experiencing a turbidity breakthrough leading to poor effluent water quality. A filter backwash is required when either of the above condition occurs. Media filters are typically backwashed with finished water at 15 to 20 gpm/sf with the bed expansion being between 15 and 30 percent. Backwash cycles are generally 10 to 20 minutes in duration. Air scour is generally used during backwash to enhance the cleaning of the filter media.

Dual media filters (GAC over sand) rated for operation up to 9 gpm/sf (West Sacramento)

At the end of a backwash cycle, some particles remain trapped within the filter bed. When a filter is returned to service after backwashing, these particles are carried into the filter effluent, causing elevated turbidities and particle counts during the initial filtration period. A "filter-to-waste" step is generally required before a filter is put back in to normal filtration after a backwash. The filtered water collected during this period is recycled to an upstream location in the process stream or delivered to a separate treatment process.

Membrane Filtration

There are four types of pressure membrane systems that are typically used in water treatment. These are Microfiltration (MF), Ultrafiltration (UF), Nanofiltration (NF), and Reverse Osmosis (RO). Microfiltration is a low-pressure membrane process with the largest pore size membranes. Microfiltration can easily remove *Giardia lamblia* cysts and *Cryptosporidium* oocysts as well as other microorganisms, colloids, and high-molecular weight compounds. Ultrafiltration is another low-pressure membrane system that operates at a slightly higher pressure and has smaller pore size than MF. Since the membrane pore size is smaller, it can remove what MF can remove plus viruses. Nanofiltration operates at a much higher pressure than either MF or UF, but less than RO. NF is capable of removing hardness, pathogens, viruses, some dissolved organics, and organic color. RO is the membrane system with the smallest membrane pores and operates at the highest pressures. It is capable of removing most organic compounds and ions, all bacteria, viruses, microorganisms, and radionuclides. For this project, MF and UF are the membrane systems that can replace conventional surface water treatment systems at a comparable cost.

Microfiltration and ultrafiltration are hollow-fiber membrane systems that remove contaminants by physical straining (sieving). The membranes remove particulates by physically straining from the water the particles greater than the nominal pore size of the membrane. The UF membranes pore size (0.01 micron) is about one order of magnitude less than the MF pore size (0.1 micron). These membrane systems can be pressure-driven or vacuum-driven membrane processes that operate at low (5 to 50 psi) pressures and flux rates of 15 to 75 gallons/ft^2/day (gfd). Chemical conditioning of the raw-water feed is usually not required except where enhanced organics or pathogen removal is desired. Due to the projected organic levels in the raw water, a chemical coagulant will be needed to reduce dissolved organic carbon (DOC) and Disinfection Byproduct (DBP) in the finished water.

While the MF and UF systems are pressure driven, there are two basic configurations – modules mounted in pressure vessels operating under positive pressure and modules submerged in an open basin that operate under vacuum. For the positive pressure system, the water is pumped through the membranes. For the vacuum system, the membrane is submerged in a metal or concrete tank and the water is pulled through the membrane by a pump. The submerged systems operate at a lower transmembrane pressure than do pressure systems.

Most membranes used in municipal water treatment are prepared from synthetic organic polymers. These membranes include those supplied by USFilter/Memcor, Zenon, Pall, Koch, and Norit. Inorganic membranes are available, such as the NGK ceramic membranes supplied by Kruger. Although the ceramic membrane is more expensive than the other MF and UF membranes, it does offer the following advantages: High flux rates (greater than 100 gfd); direct filtration of high turbidity water; long membrane life; high water recovery; minimized Clean-in-Place (CIP) requirements. CIP involves soaking the membranes in caustic and acid solutions to remove accumulated contaminants not removed by the normal backwash process.

NGK Ceramic Membrane Installation (Japan)

The general operation of the membrane types discussed above is basically the same. Particulates, microorganisms, and colloidals are filtered from the water by the membrane. As more and more material is removed from the water, the operating pressure increases, so periodically the system is backwashed to remove the filtrate and return it back to original operating conditions. In addition to the normal backwashing, membranes need to be periodically cleaned chemically to remove any scale or particulate matter that is not removed with normal backwash. Some systems use a daily maintenance wash in which sodium hypochlorite is used. In addition to the maintenance wash, a “clean-in-place” (CIP) is used about every month to remove the accumulated organic and inorganic scales. Normally citric acid, caustic and a surfactant are used to soak the membranes during the CIP operation.

Picture of two Memcor submerged membrane systems (Yuba City, CA- upper left, and Bendigo, Australia- lower left), a Zenon 1000 membrane cassette module (South San Joaquin Irrigation District-upper right), and a Pall pressure membrane system (Yucaipa Valley Water District- lower right)

Disinfection Alternatives

Disinfection usually is the last step of a treatment process and provides the final barrier against pathogens prior to pumping to the distribution system. Types of disinfection presented in this section include ultraviolet light, chlorine, chloramines, and ozone. EPA and California Department of Public Health regulations require a certain combined log removal/disinfection pathogens based on the raw water quality. Conventional treatment with flocculation/sedimentation/filtration is given a maximum of 2.5 log removal credit of *Giardia* and 3-log removal credit of *Cryptosporidium*. Based on the raw water quality, a conventional surface water treatment plant may be required to provide an additional 2.5 log removal/disinfection for *Cryptosporidium*.

Membrane filters provide an absolute barrier against pathogens such as *Giardia*, *Cryptosporidium* and are approved by the California Department of Health Services (CDHS) for minimum four logs removal of *Giardia and Cryptosporidium*. With the use of membrane filtration, only limited disinfection is needed primarily to provide a multi-barrier approach against pathogens and to provide a chlorine residual in the distribution system. The water is disinfected using UV disinfection, Chlorine, Chloramines or Ozone which are presented in the following paragraphs

Disinfection with UV

Ultraviolet (UV) light disinfection can be used as an effective barrier for the inactivation of many waterborne pathogens. UV light wavelengths range from 200 nm to 400 nm, the germicidal range is between 230 and 260 nm. Major components of UV systems include a chamber, UV lamps, quartz sleeves, cleaning system, ballasts, and a control system. The UV lamps are housed in quartz sleeves for protection from encrustation and breakage. There are three types of UV lamps used for disinfection: low pressure, low pressure/high intensity, and medium pressure. Low pressure lamps (both low pressure and low pressure high intensity) produce a monochromatic wave that is primarily in the germicidal range. Medium pressure systems are polychromatic, producing wavelengths over the entire UV range.

The cleaning systems are necessary to keep the quartz sleeves clean so that the UV can be transmitted into the water. Cleaning frequency, as well as the type of chemicals used, depends on the water quality. Both chemical/mechanical and mechanical self-cleaning systems are available on low pressure/high intensity or medium pressure systems. Low pressure systems generally require manual cleaning.

Transmittance is the ability of UV light to travel through water. For example, high turbidity water will have a low transmittance. Waters with low transmittance will require a greater dosage of UV to achieve adequate disinfection; therefore, UV is not typically applied to high turbidity, low transmittance waters. UV irradiation would need to be applied to filtered water.

UV disinfection does not leave any residual in the finished water. Therefore, if UV is used as the primary disinfection, a chemical disinfectant (such as chlorine or chloramines) will still be needed to protect water in the distribution system as required by regulation. Chloramines are not required for low TOC waters such as found in the proposed Mokelumne River water supply and will therefore be eliminated from further consideration.

The advantage of UV disinfection compared with using chlorine is that UV disinfection does not produce known disinfection by products (DBPs) and UV is proven to inactivate *Cryptosporidium* oocysts. Because a chlorine residual is required for water leaving a surface water treatment plant, the lack of DBP formation by UV is of little value since DBPs could be formed in the distribution system. However, since chlorine is not effective in *Cryptosporidium* oocysts inactivation, UV disinfection may be necessary to comply with the regulatory requirements for pathogen removal at the proposed SWTF, if media filtration is selected. For source waters with low TOC such as the Mokelumne River, UV disinfection is normally not used after membrane filtration because membranes are able to remove both *Cryptosporidium* oocysts and *Giardia* cysts.

Chlorine

Chlorine in the form of chlorine gas or sodium hypochlorite has been the most widely used chemical for drinking water disinfection. Chlorine is a relatively inexpensive disinfectant, and it has been very effective for the inactivation of many kinds of microorganisms. This has contributed to its widespread usage.

Free chlorine has some limitations that can be handled in the design:

First, its effectiveness is pH dependent. At pH values above 7, hypochlorous acid (HOCl), the more powerful form of free chlorine, disassociates to form hypochlorite ion, OCl-, a weaker disinfectant. Thus, as the pH increases above pH 7, free chlorine disinfection is less effective. To address this issue, the clearwell will be baffled and sized to provide the needed contact time.

Second, using free chlorine as a disinfectant forms DBPs such as trihalomethane (THM) and haloacetic acid (HAA) if TOC levels are high. The average TOC level in the raw water is less than 2.0 mg/L which minimizes the concern for DBPs. Coagulant can be fed to reduce TOC levels, if needed.

Third, chlorine is not an effective disinfectant for *Cryptosporidium*. UV disinfection or membranes can be utilized to inactivate or remove *Cryptosporidium*.

Chlorine has been used effectively as a disinfectant for many years by many utilities. The use of free chlorine at the proposed SWTF as the primary disinfectant and to provide a chlorine residual in the distribution system will be a viable following membrane filtration. For conventional treatment, UV disinfection may be requited as the primary disinfectant with chlorine used for the distribution system residual.

Chloramines

Chloramines have become more widely used due to their ability to provide disinfection without substantial THM formation. Taste and odor control and maintenance of a more stable residual in distribution systems are other benefits of chloramine usage. If improperly managed, however, the application of chloramines can support bacterial growth in the distribution system as well as cause nitrification problems. Another drawback of chloramines is that if used, kidney dialysis patients and people with fish tanks must be informed to remove the chloramines or risk of damage to dialysis equipment or killing of fish.

Chloramination is accomplished by combining free chlorine with ammonia or an ammonium salt, to form chloramine. Chloramine is not as strong as chlorine for disinfection, and it is not recommended as a primary disinfectant by the USEPA. Chloramine does, however, form a persistent disinfectant residual, and is used by numerous water utilities for maintenance of a residual in the distribution system. Chloramine is slower to react with substances on the walls of water mains, thus it has a better opportunity to penetrate tubercles and biofilms and kill resident bacteria.

Chloramination would not be suitable as the only disinfectant, but chloramines are effective secondary disinfectants for maintenance of a residual in the distribution system. Chloramination is not considered a viable secondary disinfectant for the proposed SWTF. It should only be considered if TOC levels become higher and DBP formation becomes a concern.

Ozone

Ozone is more effective than other chemical disinfectants against *Cryptosporidium*. Ozone must be generated on site and it dissipates rapidly in water so that a residual can not be maintained with ozone. Ozone also breaks down organics in water into smaller molecules that are more easily used by microorganisms. These organic molecules must be removed with a biological active filter to minimize biological growth in the distribution system. In water treatment applications ozone is used more frequently as an oxidant for taste and odor control than as a disinfectant. Given its high expense, ozone is not justified for treating water from the Mokelumne River.

Alternatives for Ancillary Treatment

In addition to the three basic treatment categories discussed above: pretreatment, filtration, and disinfection; many other ancillary treatment units and/or chemicals are needed to achieve the treatment goals such as providing taste and odor removal and corrosion control. The ancillary treatment units and chemicals appropriate to membrane filtration and conventional filtration are incorporated into the two treatment alternatives discussed in the following sections.

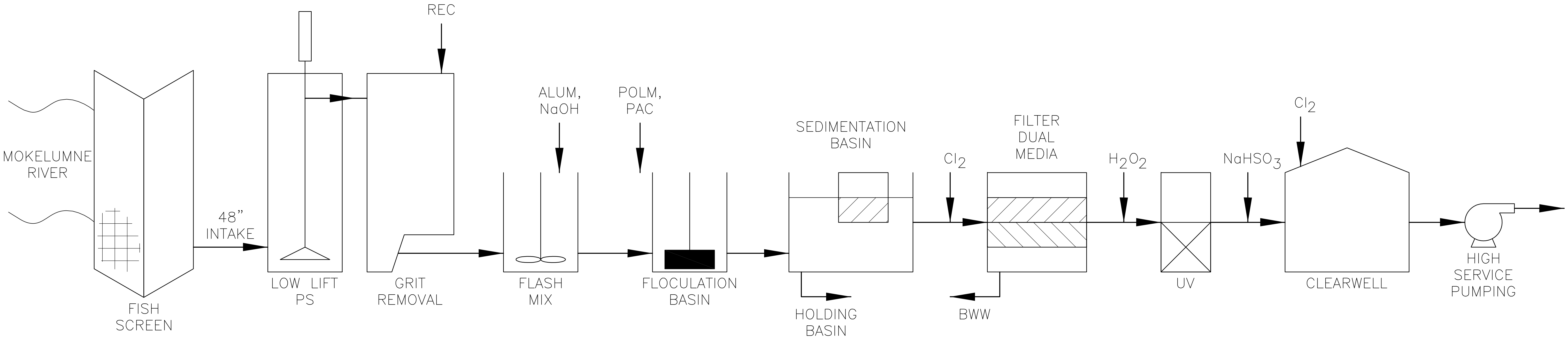
Conventional Treatment Alternative

Schematic

A schematic of the conventional treatment process train for the City of Lodi SWTF is presented in Figure 2. The schematic shows onsite solids handling with disposal to a landfill. If determined to be cost-effective, the solids from the plate settler could be discharged directly to the sewer for processing at the City’s White Slough Water Pollution Control Facility.

Design Criteria

The design criteria of the conventional treatment system are summarized in Table 8.



CONVENTIONAL TREATMENT

1
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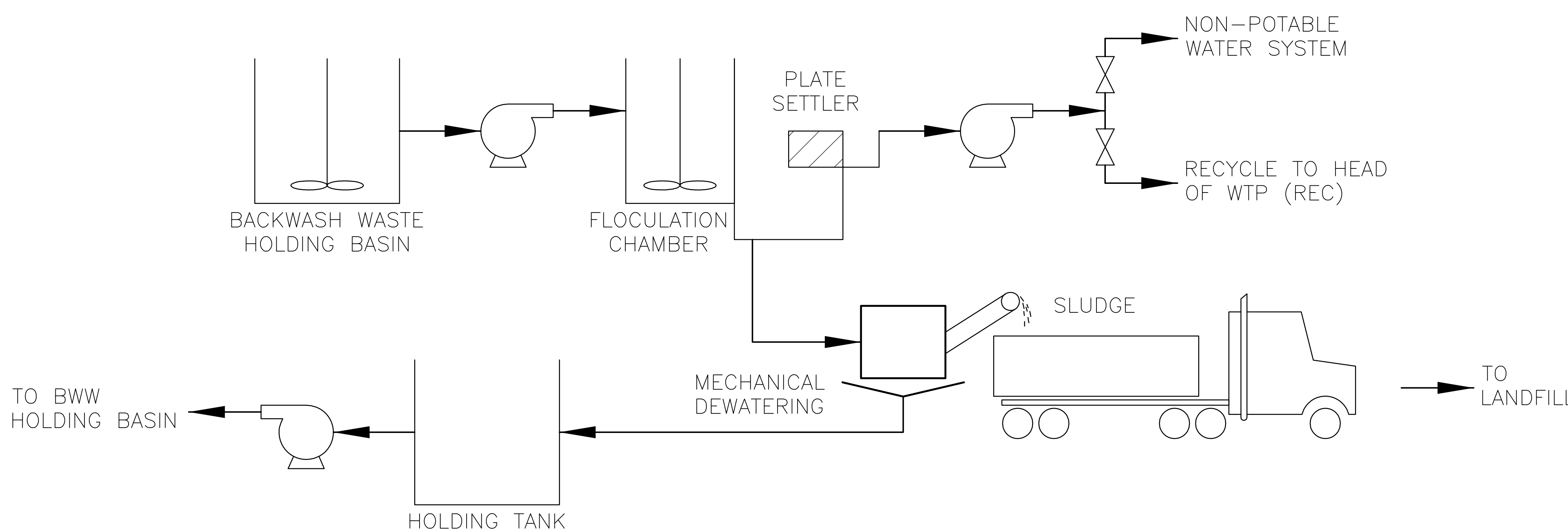

CONVENTIONAL WTP SOLIDS HANDLING

2
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SCALE: NONE

FLOW SCHEMATIC
CONVENTIONAL TREATMENT

CITY OF LODI – SURFACE WATER TREATMENT FACILITY

DATE
6/19/07

FIGURE
2

Table 8. Conventional Treatment Alternative Design Criteria

Item	**Value**
Low Lift Pump Station:	
Pump Station Dimension	50 feet x 60 feet
Number of Pumps	4 (3 working, 1 standby)
Pump Capacity	3,000 gpm @ 30 feet TDH
Pump Motor Information	1,800 rpm max; 40 HP each
Flash Mix:	
Inline Mixer	2 HP
Mixing intensity (G Value)	1,000 Second^{-1}
Flocculation Basin (3), Each Basin:	
Flow	3,000 gpm
Detention Time	20 minutes
Volume	8,021 cubic feet
Length	40 feet
Width	16 feet
Water Depth	12.5 feet
Sedimentation With Plate Settlers (2), Each Plate Settler:	
Flow	4,500 gpm
Detention Time	30 minutes
Volume	135,000 gal
Length	50 feet
Width	24 feet
Water Depth	15 feet
Surface Loading For Each Plate	0.3 gpm/ft^2
Dual Media Filters (4 total, 3 working 1 standby), Each Filter:	
Flow	3,000 gpm
Max Filtration Rate	6.0 gpm/ft^2
Filter Area	500 square feet
Filter Media	24 inch anthracite and 12 inch sand
Backwash Water	20 gpm/ft^2 maximum
Backwash Air	5 scfm/ft^2 maximum
UV Reactors (3 total, 2 working 1 standby), Each Reactor:	
Maximum Flow	4,500 gpm
Average Flow	3,000 gpm
Minimum Flow	1,500 gpm
Design Dose	40 mJ/cm^2 (for 4 log *Cryptosporidium* disinfection)
Filtered Water UV Transmittance	55 percent
Clearwell:	

Item	Value
Capacity	2.0 MG
Dimension	120 feet diameter by 24 feet deep
Baffling system	Hypalon baffles to achieve T_{10}/T ratio of 0.75
High Service Pumping:	
Pump Station Dimension	50 feet x 60 feet
Number of Pumps	4 total (3 working, 1 standby)
Pump Capacity	3,000 gpm @ 200 feet TDH
Pump Motor Information	1,800 rpm max; 200 HP each (2 motors operated with VFDs)
Backwash Holding Basin:	
Dimension	70 feet x 70 feet x 12 feet (deep)
Volume	432,000 gallon (two filter backwash volumes)
Backwash Recovery Plate Settler:	
System Components	Flash mix tank, flocculation tank, inclined plate clarifier, thickener
Capacity	1.5 MGD
Residuals Handling System [1]:	
Design solids generation rate	900 lb/day (dry solids basis)
Plate Settler/Gravity Thickener Footprint	20 feet W x 30 feet L x 25 feet H
Dewatering Equipment Type	Slow speed screw press
Dewatering Equipment Feed Rate	50 gpm
Equipment Area Dimension	40 feet x 60 feet
Chemical Area (include Alum, NaOH, Polymer, Chlorine, PAC, $NaHSO_3$, H_2O_2):	
Dimension	60 feet x 60 feet
Alum Dose	20 mg/L maximum, 10 mg/L average
NaOH Dose	20 mg/L maximum, 10 mg/L average
Polymer Dose	0.5 mg/L maximum, 0.2 mg/L average
Chlorine Dose	2.5 mg/L maximum, 1.0 mg/L average
PAC Dose	15 mg/L maximum, periodic for T&O control
$NaHSO_3$	3 mg/L maximum (optional)
H_2O_2	3 mg/L maximum (optional)

1. If residuals are discharged to the sewer, the screw press will not be needed and 600 sf less building space will be required.

Building Considerations

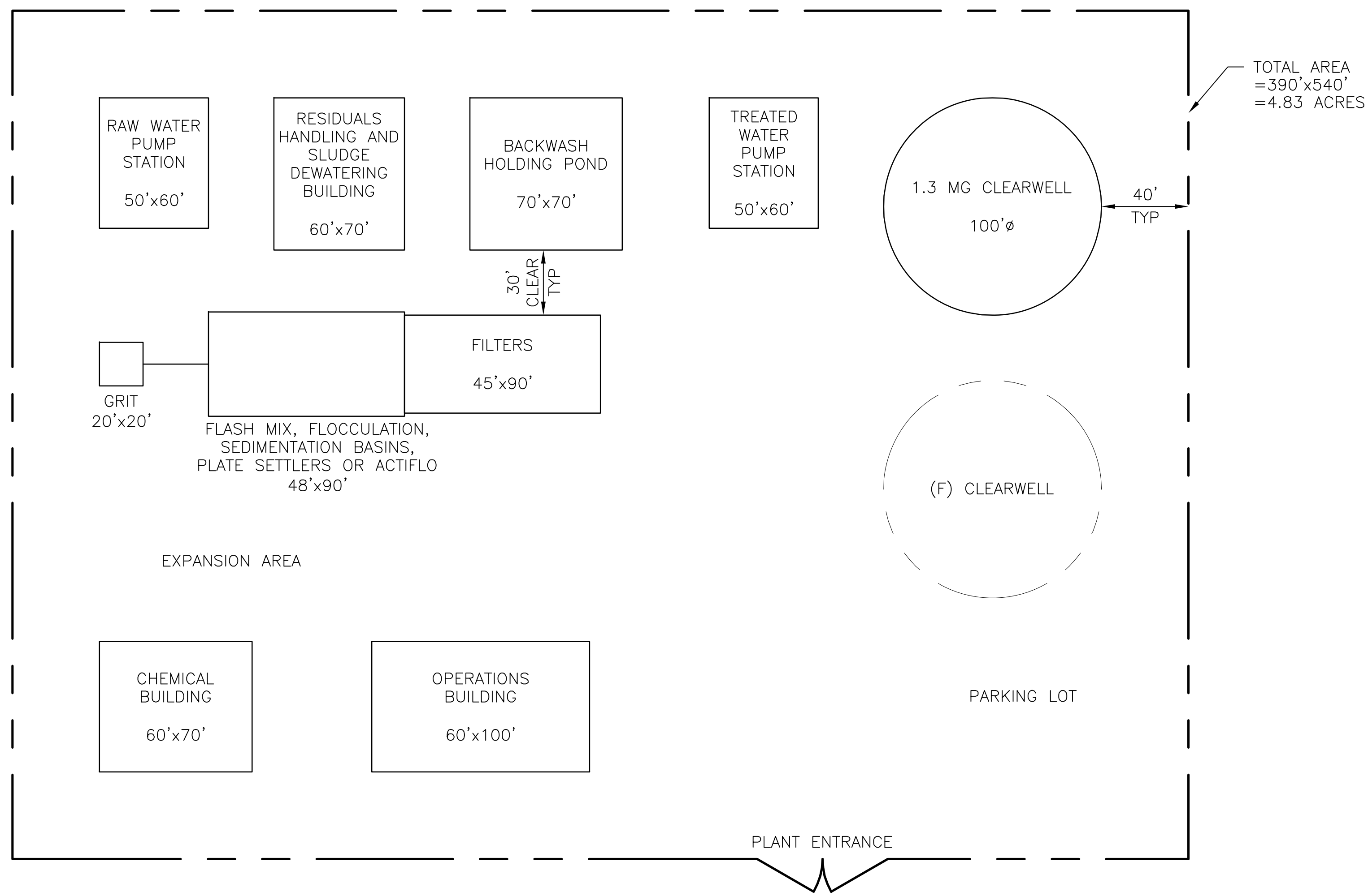
The chemical storage and feed systems, and dewatering equipment should be housed in a single building or two separate buildings. In addition to the above, building space should be provided for a lobby, offices for operations staff, a meeting room, a small laboratory for routine water quality analysis, storage room, and a maintenance/workshop room. The building architecture will be selected to enhance and compliment the surrounding area.

Site Layout

A conceptual site layout of the conventional treatment process is presented in Figure 3.

Capital and O&M Costs

Capital and O&M costs for conventional treatment are presented in Table 9. These are planning level costs for purposes of comparing conventional and membrane treatment alternatives. The cost estimates do not include additional elements of the project such as well site improvements and distribution piping additions, nor do they reflect a specific site and associated development costs. This preliminary estimate assumes that sludge is dewatered on-site and then hauled to a landfill for disposal.



PLANT LAYOUT

SCALE: 1"=50'

HDR

PLANT LAYOUT
CONVENTIONAL TREATMENT

CITY OF LODI – SURFACE WATER TREATMENT FACILITY

DATE 6/19/07

FIGURE 3

Table 9. Conventional Treatment Alternative Capital and O&M Costs Preliminary Estimates

Item	Unit Cost	Quantity	Total
Mobilization, Demobilization, General Conditions	$ 1,500,000	1	$ 1,500,000
Site work (general)	$ 850,000	1	$ 850,000
Landscaping	$ 250,000	1	$ 250,000
Site Piping	$ 1,500,000	1	$ 1,500,000
Raw Water Pump Station - 9,200 gpm	$ 700,000	1	$ 700,000
Flash mix, flocculation and sedimentation basin	$ 0.28	12,000,000	$ 3,360,000
Dual media filters, sf	$ 1,800	2,000	$ 3,600,000
Chemical Systems	$ 800,000	1	$ 800,000
Finished Water Storage Tank (1.3 MG steel)	$ 0.65	1,300,000	$ 845,000
Finished Water Booster Pump Station - 8,340 gpm	$ 800,000	1	$ 800,000
Backwash holding tank	$ 0.80	300,000	$ 240,000
Backwash Residuals Handling System	$ 1,200,000	1	$ 1,200,000
Operations Building - 15,000 SF	$ 200	10,000	$ 2,000,000
SUBTOTAL			$ 17,645,000
Electrical Power Distribution Systems			$ 2,647,000
Instrumentation and Controls			$ 529,000
SUBTOTAL WTP			**$ 20,821,000**
Unaccounted for Items (5%)			$ 1,041,000
Contingency (20%)			$ 4,164,000
TOTAL CONSTRUCTION COST			**$ 26,026,000**
Engineering: design, services during construction, and construction management			$ 5,205,000
Bond financing expenses (does not include interest)			$ 312,000
TOTAL CAPITAL COST			**$ 31,543,000**
ANNUAL O&M COSTS			
CHEMICALS:			
CHLORINE (CT, 3 mg/L)	$0.30	54,750	$16,425
POLYMER (0.2 PPM, FILTER AID)	$5	3,650	$18,250
ALUM (12 PPM)	$0.15	440,000	$66,000
LABOR, HR	$40	9,000	$360,000
POWER @ $.07/kW hr	$0.07	3,910,000	$273,700
SLUDGE DISPOSAL, LS	$24,000	1	$24,000
SED BASIN & FILTER EQUIP REPLACEMENT	$35,000	1	$35,000
TOTAL ANNUAL O&M COSTS			**$793,375**
PRESENT WORTH O&M COSTS	5%, 20 years		**$9,887,000**
TOTAL PRESENT WORTH			**$41,430,000**

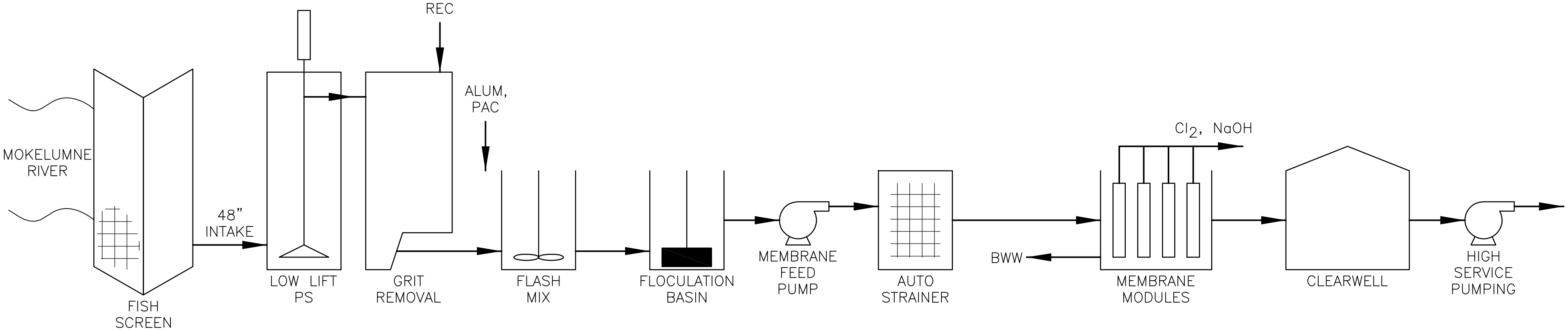
Membrane Treatment Alternative

Schematic

A schematic of the membrane treatment process train for the City of Lodi SWTF is shown in Figure 4.

Design Criteria

The design criteria of the membrane treatment system based on a pressure vessel membrane configuration are summarized in Table 10.



MEMBRANE TREATMENT 1 –

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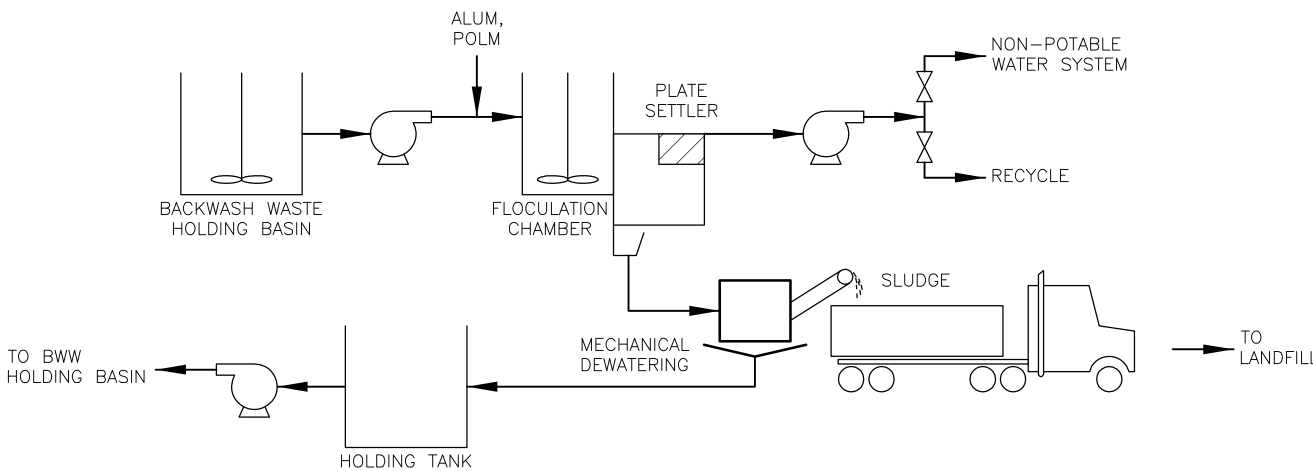


MEMBRANE SOLIDS HANDLING 2 –

SCALE: NONE

FLOW SCHEMATIC
MEMBRANE TREATMENT

CITY OF LODI – SURFACE WATER TREATMENT FACILITY

DATE 6/19/07

FIGURE 4

Table 10. Membrane Treatment Alternative Design Criteria

Item	Value
Low Lift Pump Station:	
Pump Station Dimension	50 feet x 60 feet
Number of Pumps	4 (3 working, 1 standby)
Pump Capacity	3,000 gpm @ 30 feet TDH
Pump Motor Information	1,800 rpm max; 40 HP each
Flash Mix:	
Inline Mixer	2 HP
Mixing intensity (G Value)	1,000 $Second^{-1}$
Flocculation Basin (3), Each Basin:	
Flow	3,000 gpm
Detention Time	10 minutes
Volume	4,011 cubic feet
Length	40 feet
Width	8 feet
Water Depth	12.5 feet
Feed pumps/Autostrainers:	
Feed pump: Number Capacity Horsepower	1 per train 1,500 gpm @80 ft TDH 40 hp
Autostrainers Type/Number	Automatic Self-cleaning with 0.5 mm screen/3
Flow	3,000 gpm
Membrane Trains (7 total, 6 working 1 standby), Each Train:	
Net Capacity	2.0 MGD
Number of Modules per train	84
Water Temperature	15^{0}C Summer, 5^{0}C Winter
Instantaneous Flow per Module	17.5 gpm
Design Flux	55 gal/SF/day (gfd)
Backwash Interval	30 minutes
CIP Interval	60 days
Chlorine Maintenance Wash Interval	36 hours
Acid Maintenance Wash Interval (if needed)	120 hours
Estimated Recovery	95%
CIP Waste	1,400 gpd
Maintenance Wash Waste	22,400 gpd
Clearwell:	
Capacity	2 MG
Dimension	120 feet diameter by 24 feet deep
Baffling system	Hypalon baffles to achieve T_{10}/T ratio of 0.75

Item	Value
High Service Pumping:	
Pump Station Dimension	50 feet x 60 feet
Number of Pumps	4 (3 working, 1 standby)
Pump Capacity	3,000 gpm @ 200 feet TDH
Pump Motor Information	1,800 rpm max; 200 HP each (2 motors on VFDs)
Backwash Holding Tank:	
Dimension	40 ft diameter x 16 ft high
Working Volume	130,000 gallon
Backwash Recovery Plate Settler:	
System Components	Flash mix tank, flocculation tank, inclined plate clarifier, thickener
Capacity	1.0 MGD
Residuals Handling System[1]:	
Design solids generation rate	500 lb/day (dry solids basis)
Plate Settler/gravity thickener footprint	15 feet x 25 feet
Dewatering Equipment Type	Slow speed screw press
Dewatering Equipment Feed Rate	25 gpm
Equipment Area Dimension	30 feet x40 feet
Chemical Area (include Alum, NaOH, Polymer, Chlorine, PAC, $NaHSO_3$, H_2O_2):	
Dimension	60 feet x 60 feet
Alum Dose	20 mg/L maximum, 10 mg/L average
NaOH Dose	20 mg/L maximum, 10 mg/L average
Polymer Dose	0.5 mg/L maximum, 0.2 mg/L average
Chlorine Dose	2.5 mg/L maximum, 1.0 mg/L average
PAC Dose	15 mg/L maximum, periodic for T&O control
$NaHSO_3$	3 mg/L maximum (optional)
H_2O_2	3 mg/L maximum (optional)

1. If residuals are discharged to the sewer, the screw press will not be needed and 600 sf less building space will be required.

Building Considerations

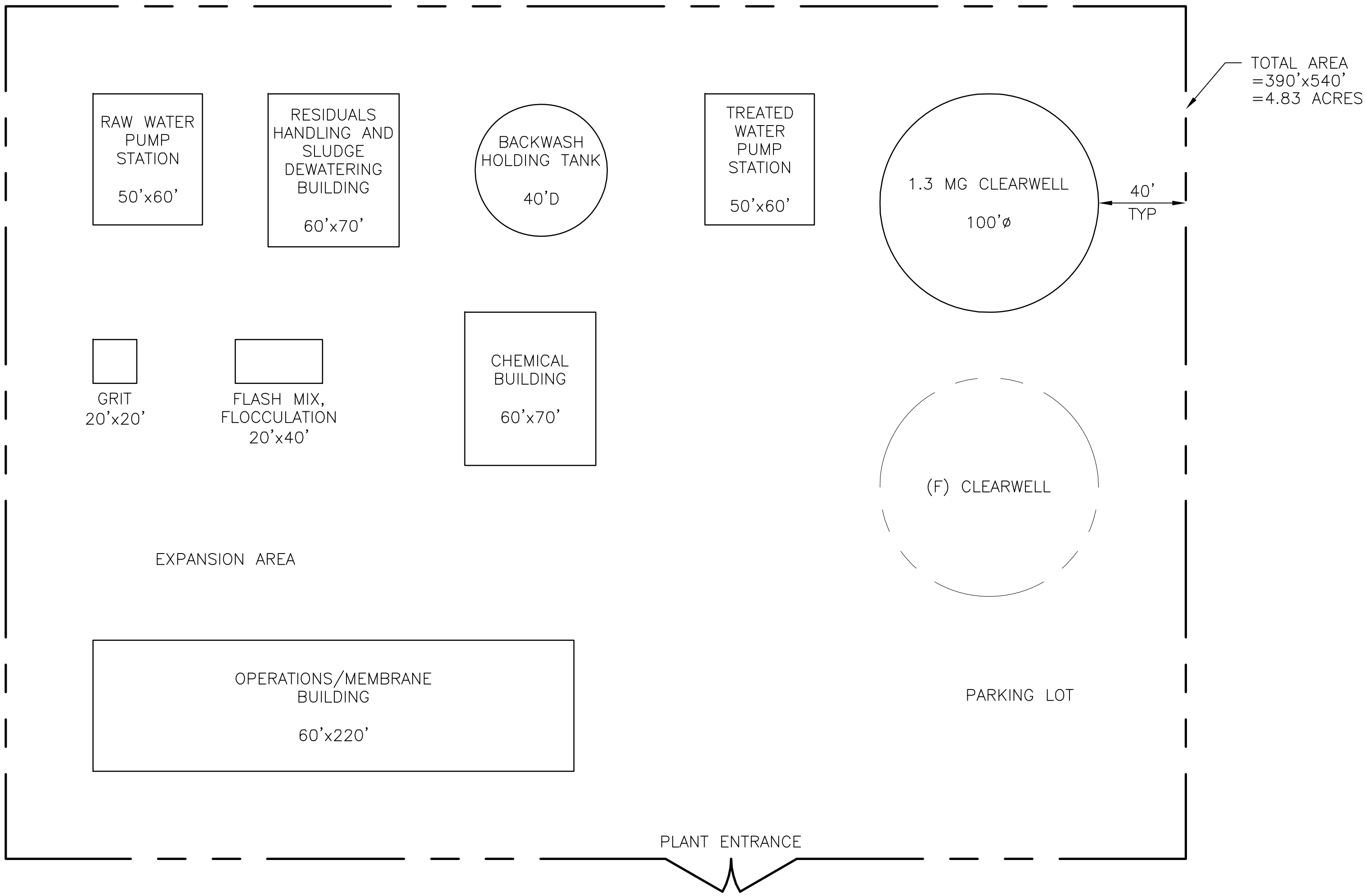
The membrane equipment, chemical storage and feed systems, and dewatering equipment should all be housed in a single building or separate buildings. In addition to the above, building space should be provided for a lobby, offices for operations staff, a meeting room, a small laboratory for routine water quality analysis, storage room, and a maintenance/workshop room. For prudent planning, the building should be oversized to accommodate addition of future membrane trains should they be needed. The building architecture will be selected to enhance and compliment the surrounding area. Examples of membrane plant operations buildings are shown in the photos below.

Membrane Operations Building (Yucaipa Valley Water District)

Membrane Operations Building (Roanoke, VA)

Site Layout

A conceptual site layout of the membrane treatment process is presented in Figure 5.



PLANT LAYOUT

SCALE: 1"=50'

PLANT LAYOUT
MEMBRANE TREATMENT

CITY OF LODI – SURFACE WATER TREATMENT FACILITY

DATE: 6/19/07

FIGURE: 5

Capital and O&M Costs

Capital and O&M costs for membrane treatment are presented in Table 11. These are planning level costs for purposes of comparing conventional and membrane treatment alternatives. The cost estimates do not include additional elements of the project such as well site improvements and distribution piping additions, nor do they reflect a specific site and associated development costs. This preliminary estimate assumes that sludge is dewatered on-site and then hauled to a landfill for disposal.

Table11. Membrane Treatment Alternative Capital and O&M Costs Preliminary Estimates

Item	Unit Cost	Quantity	Total
Mobilization, Demobilization, General Conditions	$1,500,000	1	$ 1,500,000
Site work (general)	$850,000	1	$ 850,000
Landscaping	$ 250,000	1	$ 250,000
Site Piping	$1,500,000	1	$ 1,500,000
Raw Water Pump Station - 9,200 gpm	$700,000	1	$ 700,000
Autostrainers	$250,000	1	$ 250,000
MF Membrane Filtration System (12 mgd)	$ 0.60	12,000,000	$ 7,200,000
Chemical Systems	$ 500,000	1	$ 500,000
Finished Water Storage Tank (1.3 MG steel)	$0.65	1,300,000	$ 845,000
Finished Water Booster Pump Station - 8,340 gpm	$800,000	1	$ 800,000
Backwash holding tank	$0.80	100,000	$ 80,000
Backwash Residuals Handling System	$800,000	1	$ 800,000
Operations Building - 15,000 SF	$200.00	15,000	$ 3,000,000
SUBTOTAL			$18,275,000
Electrical Power Distribution Systems			$ 2,741,000
Instrumentation and Controls			$ 548,000
SUBTOTAL WTP			$ 21,564,000
Unaccounted for Items (5%)			$ 1,078,000
Contingency (20%)			$ 4,313,000
TOTAL CONSTRUCTION COST			$ 26,955,000
Engineering: design, services during construction, construction management			$ 5,391,000
Bond financing expenses			$ 323,000

Item	Unit Cost	Quantity	Total
TOTAL CAPITAL COST			**$32,669,000**
ANNUAL O&M COSTS			
CHEMICALS:	Unit Cost	Quantity	Total
CHLORINE (CT), LB	$0.30	54,750	$16,425
CHLORINE (CIP), LB	$0.30	12,000	$3,600
CITRIC ACID (50% W/W), LB	$0.50	4,000	$2,000
SODIUM BISULFITE (38% W/W), LB	$0.50	3,400	$1,700
SODIUM HYDROXIDE (50% W/W), LB	$0.08	3,400	$272
ALUM (3 PPM), LB	$0.15	92,000	$13,800
LABOR, HR	$40	7,000	$280,000
POWER @ $.07/kW hr	$0.07	4,038,000	$282,660
SLUDGE DISPOSAL, LS	$4,000	1	$4,000
MEMBRANE REPLACEMENT (10 YEAR LIFE), LS	$25,000	1	$25,000
TOTAL ANNUAL O&M COSTS			**$613,032**
PRESENT WORTH O&M COSTS (5%, 20 YEARS)			**$7,640,000**
TOTAL PRESENT WORTH (CAPITAL + PW O&M)			**$40,309,000**

Advantages and Disadvantages of Alternatives

Both conventional filtration and membrane filtration can be used at the proposed City of Lodi's SWTF. The advantages and disadvantages of membrane filtration compared with conventional medial filtration are summarized in this suction.

Advantages

The advantages of the membrane process are:

- Membranes provide a positive barrier for the removal of all microbials and most pathogens, which increases the flexibility of the system to meet future regulations.
- The overall footprint for the facility is smaller than conventional surface water treatment processes.
- The overall treatment process is easy to expand by adding trains.

- With the automation of the process and the entire plant, the operational personnel requirement is lower.

- Less pretreatment is required only flocculation is needed. Sedimentation is not necessary.

- Less disinfection is required and thus lower DBP concentration is expected.

- Less chemical for flocculation and pH adjustment is needed.

- The operation of the facility is flexible to accommodate changing raw water quality.

- The total present worth of the membrane alternative is slightly less than for the conventional treatment alternative.

The advantages of Conventional treatment are:

- It is a proven process with many years of experience.

- The capital cost is slightly less than for membranes.

Disadvantages

The disadvantages of the Membrane process are:

- During high turbidity events of winter runoff, the plant capacity may be reduced and the City's groundwater wells may have to be used as the primary source of water supply. This is not a significant problem because the wells have ample capacity to meet winter demands.

- The membrane treatment system will require approximately 2.5 percent more power consumption compared to conventional filtration.

The disadvantages of Conventional treatment are:

- Conventional filtration relies on chemical destabilization of particles for pathogen removal and is not as reliable as membrane treatment.

- Greater chemical usage and annual operating costs.

- Higher present worth cost.

Recommendations

Based on the evaluation presented above, it is our recommendation that the City select low pressure membrane filtration for the proposed SWTF. The decision on which low pressure membrane system to use will be made based on further evaluation during the predesign stage. The City could decide whether to pre-purchase the membrane system after further evaluation of individual membranes or provide a general design and select the membrane system during the project bid period.